PCB FIELD TEST KIT EVALUATION

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PCB FIELD TEST KIT EVALUATION

Report prepared for the
Commercial Chemicals Branch

by

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ABSTRACT

The Environmental Protection Service, Ontario Region, National Capital Area Operations, conducted evaluations of three polychlorinated biphenyl field test kits manufactured by McGraw-Edison Company, Syprotec Inc., and Dexsil Chemical Corporation. Kit performance was evaluated first in the lab and then in the field.

The lab evaluation involved only the McGraw-Edison and Syprotec kits which were tested to determine their effectiveness in identifying the presence and concentration of PCBs. Appendix B presents the TSB report of the preliminary evaluation.

For the field evaluation, National Defence personnel assisted in collecting 86 oil samples in November, 1983, from out-of-service transformers awaiting disposal at Canadian Forces Bases Ottawa North and South. Seventy-eight of the 86 oil samples were tested with the field test kits. Of these, 40 were selected and submitted to Syprotec Analytical Services Inc. for analysis by gas chromatography (GC); the results of the analyses were used as a reference with which to compare the results obtained from the field test kits. Of the 40 samples analyzed by Syprotec, five were also submitted to the Technical Services Branch organic laboratory for confirmation of the results obtained by Syprotec.

Results of the study indicate that the overall performance of the kits is fairly consistent, although some variation was observed between results obtained using the kits and those obtained using the gas chromatograph. The confirmation tests using GC were in agreement with the Dexsil kit results for 94% of the samples, the Syprotec kit for 90%, and the McGraw-Edison kit for 80%. The report identifies the advantages and disadvantages of each kit, lists operational problems, and recommends the use of PCB field test kits as an alternative to gas chromatography in certain cases.

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CONCLUSIONS

1) In general, all three test kits are quite reliable for determining the presence of PCBs in oil samples.
2) The test kits, at $6 per analysis, offer an excellent alternative to GC, at $60 per analysis.
3) Problems may be experienced with the operation of the Syprotec and McGraw-Edison kits. Probe problems occurred with the McGraw-Edison kit; chemical reagent problems occurred with the Syprotec kit.
4) All three kits may indicate the presence of PCBs when in fact some other chlorinated compound is present (e.g., chlorinated benzene compounds).
5) Special precautions may be required when shipping the Syprotec kit since it does contains a PCB standard (at about the 35 ppm concentration).
6) The Dexsil kit was found to be the best overall kit for use as a screening tool in determining the presence of PCBs.

1 INTRODUCTION

Polychlorinated biphenyls (PCBs) are inert chlorinated aromatic hydrocarbons with the general formula $C_{12}H_{(10-x)}Cl_x$. Historically, PCBs have been used in a wide variety of applications. Because of their relative nonflammability and excellent dielectric properties, PCBs were used extensively as a dielectric fluid in electrical equipment such as transformers, capacitors, and associated electrical components.

During the 1960s and 1970s the harmful characteristics of PCBs were identified, namely their slow biodegradability, potential for bioaccumulation, and their association with severe health problems. The Chlorobiphenyl Regulations No. 1, made under the Environmental Contaminants Act, were promulgated in 1977 and amended in 1980. They restricted the use of PCBs to specified closed applications such as use in transformers. The Chlorobiphenyl Regulations No. 2 and No. 3, which came into effect on August 1, 1985, prohibit the sale of equipment designed to use PCBs, and the release of PCBs to the environment, respectively. In addition to the PCB-filled electrical equipment mentioned above, many oil transformers are contaminated with PCBs. Because of the requirements of Regulations No. 2, Crown Assets Disposal Corporation (CADC) is demanding that owners of electrical equipment determine the concentration of PCBs in the dielectric fluid before CADC accepts the equipment for re-sale.

For several years, the only available method of detecting PCBs was gas chromatography (GC). In 1983, two companies, Centec Analytical Services Inc. of Salem Virginia (later purchased by McGraw-Edison Company of Pittsburgh, Pennsylvania), and Syprotec Inc. of Pointe-Claire, Québec, developed test kits (McGraw-Edison PCB Field Test Kit, and PCB Kwik-Skrene Kit, respectively) designed to measure PCBs in the field for screening purposes. In 1984, the Dexsil Chemical Corporation, Hamden, Connecticut, made available the Clor-N-Oil PCB Screening Kit.

In 1983 the Commercial Chemicals Branch, the Technical Services Branch, and the National Capital Area Operations of the Environmental Protection Service purchased the Syprotec kit and rented the McGraw-Edison kit to evaluate their effectiveness and determine the advantages and disadvantages of each. Later during the study, the Dexsil kit was purchased for examination. The evaluation program was divided into two parts. The Technical Services Branch group tested the kits with "spiked" samples at different concentrations for Aroclors 1242, 1254 and 1260. The National Capital Area Operations group tested the kits in the field on samples obtained from Department of National Defence (DND) transformers. Seventy-eight transformers were tested.

The purpose of the study was to evaluate each of the test kits by comparing test kit results with those obtained using GC. Each kit was judged for accuracy, ease of operation, reliability, and overall effectiveness for field applications.

2 SAMPLING PROGRAM

2.1 Origin and Quantity of Samples

With the assistance of Department of National Defence personnel, one 35-mL sample of oil was collected from each of 86 DND transformers awaiting disposal. The sampling period was from November 2 to 15, 1983. Data for the selected transformers are summarized in Tables 1 and 2. The 35-mL samples of transformer oil were placed in numbered septum vials.

2.2 Sampling Equipment and Procedure

Pyrex septum vials with a capacity of 40 mL were used to hold the samples. Each vial had a stopper consisting of a Teflon septum or liner held in place by a plastic screwcap.

Bottles, septi, and caps were cleaned using the following method:

a) soaking in RBS soap (or equivalent anionic surfactant) for two hours and scrubbing with a brush;
b) washing with regular soap;
c) rinsing three times with deionized water using 100 mL each time;
d) rinsing with acetone 3 x 50 mL;
e) rinsing with dichloromethane 3 x 50 mL;
f) rinsing with hexane 3 x 50 mL.

After examining several types of transformers and sample collection methods, it was decided that the most effective method for sampling was to open the top covers of the transformers and collect the oil sample using an automatic pipette with disposable tips.

TABLE 1 TRANSFORMER DATA FOR UNITS STORED AT OTTAWA SOUTH (UPLANDS)

Sample No.	Manufacturer	Serial No.	Date Sampled
1	G.E. ONS	487971	02-11-83
2	General Electric	-	02-11-83
3	Moloney	91725	02-11-83
4	-	SFD14	02-11-83
5	Packard	177070	02-11-83
6	Westinghouse	45H5930-11	02-11-83
7	Westinghouse	141642	02-11-83
8	Westinghouse	44H59630-11	02-11-83
9	Ferranti	SFD-11	14-11-83
10	Ferranti	SFD-12	14-11-83
11	Ferranti	SFD-13	14-11-83
12	Ferranti	248946	14-11-83
13	Ferranti	98542	14-11-83
14	Ferranti	98540	14-11-83
15	Ferranti	95541	14-11-83
16	Packard	318904	14-11-83
17	Reliance	KW8217-3	14-11-83
18	Westinghouse	268718	14-11-83
19	Ferranti	98493	14-11-83
20	Ferranti	240545	14-11-83
21	Consolidated	5580	14-11-83
22	Northern	235039	14-11-83
23	C.G.E.	235041	14-11-83
24	Cansfield	5580	14-11-83
25	Ferranti	13833	14-11-83
26	Ferranti	13834	14-11-83
27	Ferranti	13832	14-11-83
28	Ferranti	98510	14-11-83
29	Westinghouse	829429	14-11-83
30	Bepco	15828	14-11-83
31	Cansfield	5579	14-11-83
32	Cansfield	5578	14-11-83
33	Packard	160111	14-11-83
34	Packard	160110	14-11-83
35	Moloney	91724	14-11-83
36	Packard	160112	14-11-83
37	Cansfield	17525	14-11-83
38	Commonwealth	10829	14-11-83
39	Ferranti	248947	14-11-83
40	Ferranti	248948	14-11-83
41	Westinghouse	280537	14-11-83
42	SFD10	SFD10	14-11-83

TABLE 2 TRANSFORMER DATA FOR UNITS STORED AT OTTAWA NORTH (ROCKLIFFE)

Sample No.	Manufacturer	Serial No.	Date Sampled
43	Westinghouse	38564	15-11-83
44	General Electric	17634	15-11-83
45	English Electric	192890	15-11-83
46	Westinghouse	127020	15-11-83
47	Westinghouse	118523	15-11-83
48	Westinghouse	225934	15-11-83
49	Bepco	12834	15-11-83
50	Westinghouse	342014	15-11-83
51	Moloney	883383	15-11-83
52	Westinghouse	342016	15-11-83
53	Westinghouse	342019	15-11-83
54	Bepco	1366	15-11-83
55	No sample/No transformer	-	-
56	Westinghouse	33576	15-11-83
57	Westinghouse	31243	15-11-83
58	Westinghouse	LC28471	15-11-83
59	Westinghouse	371954	15-11-83
60	Westinghouse	37-385	15-11-83
61	General Electric	462887	15-11-83
62	General Electric	322916	15-11-83
63	General Electric	271929	15-11-83
64	Supreme	033661	15-11-83
65	Northern Electric	29276	15-11-83
66	Northern Electric	219274	15-11-83
67	Westinghouse	219275	15-11-83
68	Bepco	1KA639	15-11-83
69	Westinghouse	277237	15-11-83
70	Ferranti	233167	15-11-83
71	English Electric	154452	15-11-83
72	General Electric	512885	15-11-83
73	Ferranti	2-121937	15-11-83
74	General Electric	213X12B	15-11-83
75	General Electric	462885	15-11-83
76	English Electric	54480	15-11-83
77	Westinghouse	426039	15-11-83
78	Westinghouse	426097	15-11-83
79	Westinghouse	426096	15-11-83
80	Bepco	13238	15-11-83
81	General Electric	870062	15-11-83
82	General Electric	870061	15-11-83
83	General Electric	870063	15-11-83
84	Ferranti	100414	15-11-83
85	Ferranti	100415	15-11-83
86	Ferranti	100413	15-11-83
87	Moloney	96167	15-11-83

3 FEATURES OF FIELD TEST KITS

The three kits evaluated in this report all use a chloride ion detection method. The McGraw-Edison Company PCB Field Test Kit involves a three-step chemical procedure with electronic measurement and digital readout. The PCB Kwik-Skrene Kit by Syprotec Inc. and the Chlor-N-Oil PCB Screening Kit by Dexsil Corporation are simple wet chemical test kits based on the formation of chloride ions detected by a colour-forming process. Manufacturers' technical data sheets are provided in Appendix A.

3.1 McGraw-Edison (Centec Kit)

The McGraw-Edison kit (Figure 1) combines a simple, three-step chemical procedure with electronic measurement and digital readout. It is battery operated and weighs seven kilograms. PCB analysis can be performed in five minutes. The kit should be calibrated every hour or five samples, and each time it is moved to a new site. After calibration, each oil sample is analyzed using the following process:

a) Fit a clean disposable pipette tip to the 1-mL pipette. Use a pipette to transfer a sample of the oil to a reaction vial containing premeasured reagents. Cap the vial and shake for 20 seconds.

b) Use the 5-mL pipette to transfer extraction fluid to the reaction vial. Cap the vial and shake for 10 seconds. Wait two minutes for layers to separate.

c) Rinse and dry the probe. Immerse the probe in the lower layer. Mix gently for two minutes. Record the probe response on the permanent record sheet and note the contamination level. Should the contamination be greater than 50 ppm, confirmatory tests should be performed.

3.2 Syprotec (Kwik-Skrene Kit)

The Syprotec kit (Figure 2) is a simple wet chemical kit based on the formation of chloride ions which are then detected by a colour-forming reaction, a method developed by British Columbia Hydro. It is easy to use, requires no instrumentation, and consists of pipettes, chemical reagents and standard solutions.

Portions of each oil sample are placed in separate test tubes for testing. "Blank" and "control" solutions are also prepared as standards against which the oil samples are compared. Reagents "A", "B", and "C" are sequentially dispensed in each test tube using the precalibrated micropipettes. The layers develop; the bottom layer is examined.

FIGURE 1 MCGRAW-EDISON COMPANY (CENTEC) KIT

FIGURE 2 KWIK-SKRENE KIT BY SYPROTEC INC.

The test tube with the blank solution (10 ppm PCB Aroclor 1260 in mineral oil) will have a white colouration. The test tube with the control solution (35 ppm PCB Aroclor 1260 in mineral oil) will have a light orange colouration.

Oil samples which have a bottom layer of a lighter shade of orange than the control solution when tested contain less than 35 ppm PCBs. Those of a darker shade of orange contain more than 35 ppm of PCBs and require a confirmatory test.

An average of 50 PCB-in-oil determinations can be performed with the chemicals supplied by the manufacturer.

3.3 Dexsil (Chlor-N-Oil Kit)

The Dexsil kit (Figure 3) involves a simple procedure that reveals whether or not a given sample of transformer oil contains more than 50 ppm PCBs. It can be performed in under four minutes. No calibrations are required as all reagents are premeasured in crushable glass ampoules. The test utilizes an easy-to-understand colour transformation process. All reagents are self-contained within the kit. After pipetting the oil sample into the premarked reaction tube, no measuring or pipetting of reagents is required - they never come in contact with the person using the kit. No glassware is exposed, and each kit can be easily and safely disposed of. The procedure is:

a) Unscrew the dispenser cap from Tube 1 (with black cap). Using the polyethylene pipette, add exactly 5 mL (up to line) of transformer oil to the tube. Replace the cap securely.

b) Break the colourless ampoule (lower) in the tube by compressing the sides of the tube. Shake for several seconds. Break the gray ampoule (top) in the tube and shake thoroughly (make sure that the colourless ampoule is broken first, the gray one second). Allow to react for 60 seconds, shaking intermittently several times.

c) Remove the caps from both tubes and pour the buffer solution from Tube 2 (with white cap) into Tube 1. Replace the cap on Tube 1 and shake well for 10 seconds. Vent the tube by partially unscrewing the dispenser cap. Close securely and shake for 10 seconds. Vent the tube again by partially unscrewing the dispenser cap. Close securely and shake for 10 seconds more. The oil should no longer appear gray.

d) Allow Tube 1 to settle for two minutes. If the oil layer is on top, open flip top. Turn Tube 1 slowly upside-down and dispense exactly 5 mL of the colourless buffer solution into Tube 2 (up to line). Replace cap on Tube 2 and close cap on Tube 1. If

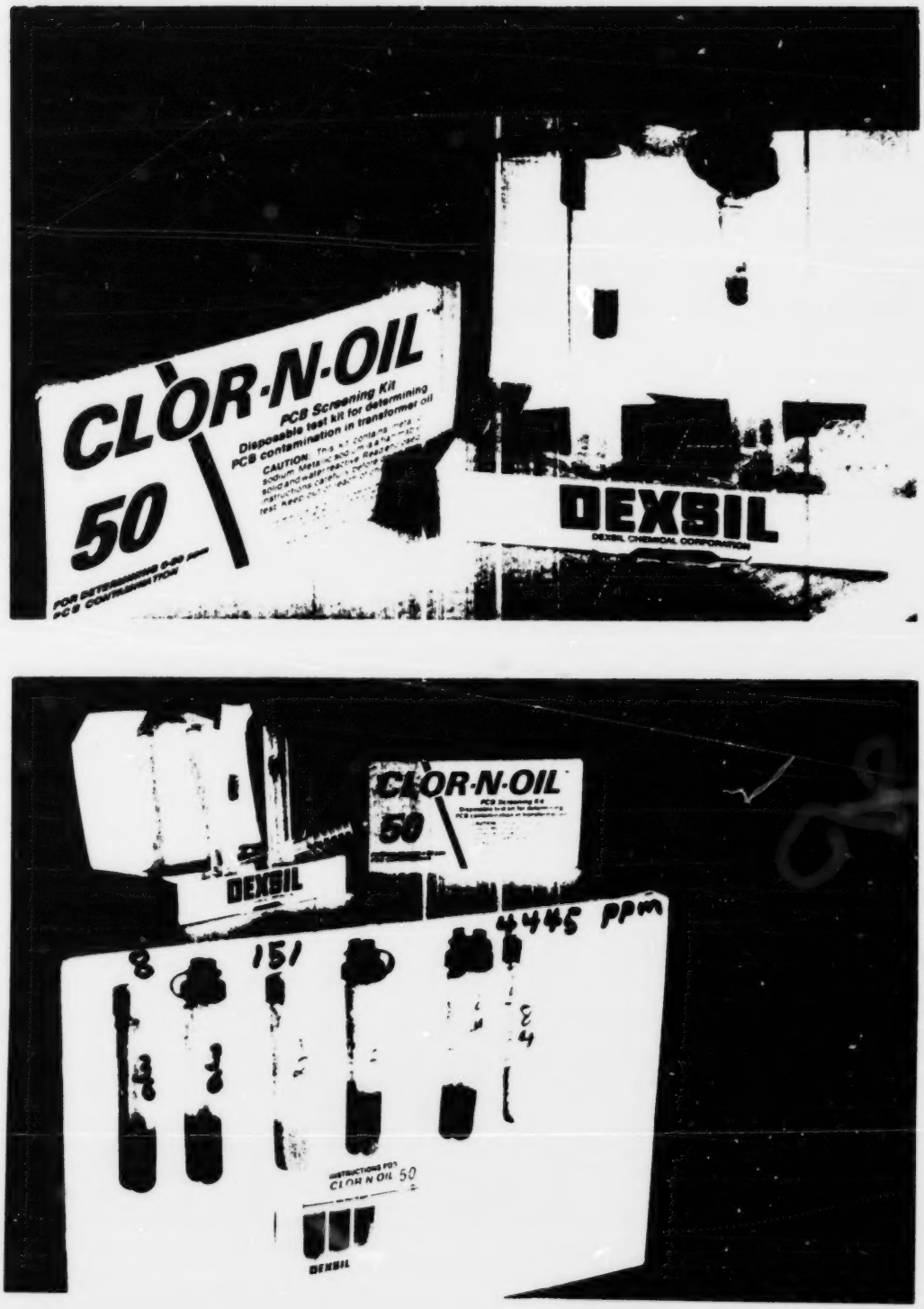


FIGURE 3 CLOR-N-OIL KIT BY DEXSIL CHEMICAL CORPORATION

oil layer is on the bottom, discontinue test at this point as the oil is primarily pure PCB and requires confirmatory tests.

e) Break the colourless ampoule (bottom) in Tube 2 and shake for a few seconds. Break the coloured ampoule (top), shake and observe colour.

f) If the solution appears purple, the oil sample contains less than 50 ppm PCB. If it appears yellow or colourless, it may contain more than 50 ppm PCB and should be tested further by a PCB specific method. Disregard any colour that may develop in a thin layer of oil which might form at top of the solution.

4 GAS CHROMATOGRAPHY EQUIPMENT AND PROCEDURES

Two laboratories, EPS Technical Services Branch (TSB) and Syprotec Inc., provided gas chromatography (GC) analysis in the evaluation study. GC was used to evaluate test kit performance: 40 of the 78 samples analyzed with the field test kits were also analyzed by Syprotec with GC, the standard method for PCB analysis. Of the 40 samples submitted to Syprotec, five were also submitted to TSB for GC analysis to check the GC results obtained by Syprotec.

4.1 Syprotec Method

Syprotec uses the U.S. Environmental Protection Agency EPA-600/4-81-045 method of analysis involving the following equipment and procedure:

Equipment

- Gas chromatograph
- One column 0V101 3%
- Electron capture detector

Procedure

- Sample → 1% hexane → sulphuric acid injection into chromatograph.
- Peaks are recorded, measured, and identified as: Aroclor 1260, Aroclor 1254, and Aroclor 1242.
- Data are compiled and reported.

4.2 TSB Method

TSB uses a modification of the U.S. EPA-600 method which requires detailed column chromatographic clean-up steps and subsequent GC quantitation using capillary columns.

Equipment

- Gas chromatograph
- One column SP2250 1.95% SP2401
- Electron capture detector

Procedure

- Sample → florisil/hexane mixture → evaporation, dilution, and injection in chromatograph
- Peaks are recorded, measured, and identified
- Data are compiled and reported.

5 ANALYTICAL RESULTS

All samples were tested for PCBs using the McGraw-Edison and Syprotec kits. Because of the limited number of Dexsil kits purchased, only 19 of the samples were analyzed with the Clor-N-Oil Kit. GC confirmation of 40 of the 78 samples analyzed with the test kits was provided by Syprotec Inc., Pointe-Claire, Québec, and the TSB laboratory verified five of the 40 samples submitted to Syprotec Inc.

Analysis for PCBs consisted of measuring Aroclor 1242, Aroclor 1254 and Aroclor 1260. Because the study involved transformer oil, emphasis was on detection of Aroclor 1260. Later confirmation by GC indicated that only Aroclor 1260 was present in the samples that tested positive using the kits. Results are presented in Table 3.

TABLE 3 PCB CONCENTRATIONS (ppm) - AROCLOR 1260

Sample No.	Centec Kit	Kwik-Skrene Kit	Clor-N-Oil Kit	Gas Chromatograph	
				Syprotec Inc.	TSB
9	7	< 35	< 50	< 2	
10	9	< 35			
11	7	< 35			
12	102	> 35	> 50	151	
13	< 6	> 35	< 50	< 2	
14	< 6	< 35			
15	6	> 35			
16	6	< 35		< 2	
17	19	> 35			
18	8	< 35	< 50		
19	< 6	> 35			
20	183	> 35	> 50	259	
21	< 6	< 35			
22	25	< 35		15	
23	23	< 35	< 50	15	
24	19	< 35			
25	47	> 35	< 50	76	
26	40	> 35		83	58.6
27	57	> 35	> 50	80	
28	15	> 35			
29	17	< 35			
30	13	< 35			
31	91	> 35	< 50	< 2	< 1
32	134	> 35		< 2	< 1
33	30	< 35		7	
34	13	< 35			
35	45	< 35		< 2	
36	66	< 35	< 50	8	
37	64	< 35		< 2	
38	49	< 35		< 2	
39	151	> 35		134	
40	163	> 35	> 50	126	
41	81	< 35		3	
42	12	< 35			
43	16	< 35			
44	12	< 35		< 2	
45	8	< 35			
46	18	< 35			
47	14	< 35	< 50	< 2	
48	14	< 35			
49	30	< 35	< 50	11	
50	44	< 35	< 50	< 2	
51	33	< 35	< 50	< 2	
52	20	< 35			

TABLE 3 PCB CONCENTRATIONS (ppm) - AROCLOR 1260 (cont'd)

Sample No.	Centec Kit	Kwik-Skrene Kit	Clor-N-Oil Kit	Gas Chromatograph	
				Syprotec Inc.	TSB
53	20	< 35			
54	27	< 35		16	
56	18	< 35			
57	20	< 35			
58	23	< 35		< 2	
59	18	< 35			
60	28	< 35		< 2	
61	22	< 35		< 2	
62	16	< 35			
63	< 6	< 35		< 2	
64	16	< 35			
65	19	< 35			
66	18	< 35			
67	15	< 35			
68	15	< 35			
69	19	< 35			
70	22	< 35		19	
71	15	< 35			
72	25	< 35		59	42.2
73	15	< 35			
74	20	< 35		5	
75	17	< 35			
76	9	< 35			
77	15	< 35			
78	14	< 35			
79	15	< 35	< 50	< 2	
80	16	< 35			
81	20	< 35		< 2	
82	31	< 35	< 50	< 2	
83	22	< 35			
84	>1046	> 35	> 50	4 445	
85	>1046	> 35		20 088	
86	>1046	> 35		35 599	
87	44	> 35	< 50	45	43.5

6 DATA INTERPRETATION

Of the 78 samples tested with the McGraw-Edison and Syprotec kits and the 18 tested with the Dexsil kit, only 40 were analyzed by Syprotec using GC. Data interpretation was therefore limited to the 40 samples analyzed using GC because one the the main objectives of the field evaluation study was to measure the effectiveness of the test kits using the results obtained from GC. A key factor in evaluating the kits was their ability to correctly identify PCBs when present in a concentration greater than 50 ppm since 50 ppm is the concentration in the Chlorobiphenyl Regulations No. 2 (Product) that effectively defines whether a specified piece of equipment is PCB or non-PCB.

6.1 McGraw-Edison Kit

Forty samples were analyzed for PCBs (Aroclor 1260) with the test kit, and later using GC. Of these, 13 were found to contain greater than 50 ppm PCBs, and 27 less than 50 ppm PCBs, using the test kit. Of the 13 samples found to contain >50 ppm, 8 samples were correct and 5 incorrect, of the 27 samples found to contain <50 ppm, 24 were correct and three incorrect as confirmed by GC. Therefore, GC analysis indicated that the kit correctly analyzed 80% of the samples.

6.2 Syprotec Kit

Forty samples were analyzed for PCBs (Aroclor 1260) with the test kit, and later using GC. Of these, 14 were found to contain greater than 35 ppm PCBs, and 26 less than 35 ppm PCBs, using the test kit. Of the 14 samples found to contain >35 ppm, 3 were incorrect; of the 26 samples tested at <35 ppm, 25 were correct and 1 incorrect as confirmed by GC. Therefore, GC analysis indicated that the kit correctly analyzed 90% of the samples.

6.3 Dexsil Kit

Nineteen samples were analyzed for PCBs (Aroclor 1260) with the test kit, and 18 of these were later analyzed using GC. Of the 18, five were found to have a concentration greater than 50 ppm, and 13 less than 50 ppm PCBs, using the test kit. Of the five samples found to contain < 50 ppm, four samples were correct and one incorrect; of the 13 samples with < 50 ppm, 13 were correct and none incorrect as confirmed by GC. Therefore, GC analysis indicated that the kit correctly analyzed 94% of the samples.

7 OBSERVATIONS

Initially, only two kits, the McGraw-Edison and Syprotec units, were to be evaluated. Three months into the study, it was discovered that a third manufacturer, Dexsil Chemical Corporation, had a PCB screening test kit named Clor-N-Oil. It was then decided to purchase 20 kits (one shelf pack) for field evaluation only.

During the laboratory evaluation phase of the study, several problems occurred with the test kits - probe problems with the McGraw-Edison kit and chemical reagent problems with the Syprotec kit. The problems are well documented in the appended laboratory evaluation report (Appendix B).

In the field evaluation phase, similar problems occurred. The McGraw-Edison probe had to be replaced twice because of erratic response that made it impossible to determine digital readout values for conversion to PCB concentrations. Chemical reagent problems with the Syprotec unit resulted in poor colour-formation reactions with no colour difference between control, blank, and oil samples. Both McGraw-Edison and Syprotec were very cooperative in correcting the situation by providing expert advice and replacement material without cost. Once the "bugs" were removed, sample analysis proceeded without further problems. The Dexsil kits performed very well.

It was observed that all kits indicated positive results in the presence of chlorinated benzenes or other chlorinated organics. That is, the kits may indicate that PCBs are present when, in fact, some other chlorinated compound is present.

The advantages and disadvantages of each test kit are summarized in Table 4.

TABLE 4 ADVANTAGES AND DISADVANTAGES OF TEST KITS

Kit	Advantages	Disadvantages
McGraw-Edison Company (Centec)	1) Identifies PCB contamination in mineral oil and provides optional soil testing equipment. 2) Identifies two varieties of PCBs: Aroclor 1242 and Aroclor 1260. 3) Expresses values in ppm. 4) Detection range of 13-1815 ppm for Aroclor 1242, and 6-1046 ppm for Aroclor 1260. 5) Company outlet in Toronto.	1) Manufactured in U.S. - capital cost of $3 200 (U.S.) - replenishment kits ordered from U.S. ($5 (U.S.)/sample) 2) Requires: - batteries, a possible source of problems - probe, a possible source of problems - calibration - care in handling electronic instrument - care in handling chemical reagents - workbench or level ground to perform the analysis - training to perform the analysis 3) Chlorinated benzenes or other chlorinated organics will form chloride ions and test positive (i.e., will indicate that PCBs are present when they may not be). 4) Possible transportation restrictions (kit contains flammable solvents).

TABLE 4 ADVANTAGES AND DISADVANTAGES OF TEST KITS (cont'd)

Kit	Advantages	Disadvantages
Syprotec Inc.	1) Manufactured in Canada. 2) Capital cost of $595 (Can.). 3) Replenishment kit produced in Canada at $5/sample. 4) Company also provides laboratory facilities in Valleyfield, Québec. 5) Does not require a power source. 6) Utilizes a colour-forming method of detection - no electrodes.	1) Identifies PCBs in mineral oil only - no soil testing. 2) Requires: - calibration - care in handling chemical reagents - good lighting conditions for colour perception - some training to perform the analysis 3) Expresses PCB values as less than or more than 35 ppm; 50 ppm not used because of perceptible differences in colouration. 4) Shelf life of chemicals is three months (refrigerated). 5) Chlorinated benzenes or other chlorinated organics will form chloride ions and test positive (i.e., will indicate PCBs are present when they may not be). 6) Possible transportation restrictions (kit contains PCBs).

TABLE 4 ADVANTAGES AND DISADVANTAGES OF TEST KITS (cont'd)

Kit	Advantages	Disadvantages
Dexsil Chemical Corporation	1) No capital cost per se - each kit is a complete unit; does one test at cost of $5.00 (U.S.); comes in shelf packs of 20 units or more at $5.00 (U.S.)/unit. 2) Does not require a power source. 3) Does not require calibration. 4) Does not require training to perform the analysis providing one reads the instructions carefully. 5) Utilizes a colour-forming method of detection - no electrodes. 6) Kit weighs 60 g and measures 25.4 x 80 x 159 mm. 7) Shelf life of chemicals is at least six months (refrigerated). 8) Safe - all chemicals are sealed in glass ampoules and never come in contact with the analyst. 9) Easiest of the three kits to operate.	1) Identifies PCBs in mineral oil only - no soil testing. 2) Manufactured in the U.S. 3) No known Canadian distributor. 4) Identifies PCBs as a group, no distinction between Aroclor 1242, Aroclor 1254, and Aroclor 1260. 5) Expresses PCB values as less than or greater than 50 ppm. 6) Chlorinated benzenes or other chlorinated organics will form chloride ions and test positive (i.e., will indicate PCBs are present when they may not be). 7) Possible transportation restrictions (contains chemicals in glass vials).

8 RECOMMENDATIONS

The following recommendations are based on the experience gained with the test kits during this study.

(i) The Dexsil kit should be selected for screening oil samples for PCB contamination (i.e., determining whether PCBs are present in a concentration above or below 50 ppm) when the analysts have limited technical expertise.

(ii) The McGraw-Edison kit, with the Dexsil kit as a back-up, should be selected for inspections or investigations by trained field personnel.

(iii) All users of the McGraw-Edison kit should have spare probes on hand.

(iv) Special care must be taken during testing to avoid contaminating the samples with chlorides through skin contact.

(v) Samples of unknown origin (e.g., at a spill site not associated with an identifiable container or transformer) that test positive should be confirmed by GC analysis. Kits may have erroneously identified PCBs when another chlorinated compound is actually present.

(vi) Test kit results near the critical 50 ppm concentration should be followed by GC confirmation. GC confirmation should also be performed when legal procedures are being considered.

ACKNOWLEDGEMENTS

The evaluation study reported herein consists of the field evaluation study with the laboratory evaluation appended. The study was coordinated by Mr. D.B. Cameron, P. Eng., Manager, NCA Operations, and subsequently by Mr. J.H. Neate and Mr. Pierre Lupien, P. Eng., Project Engineer. Administrative support and funds were provided through Mr. A. Miszkiel, P. Eng. and Mr. C.J. McDonald, Head, Controls Implementation Section, EPS-CCB, Hull, Québec.

Provisions for obtaining samples were made with the offices of the BCEO and Supply Services, CFB Ottawa South, and Mr. A.T. Downs, DCE, Colonel By Drive, Ottawa. Sample collection was conducted by Master Cpl. Lalonde, CFB, Ottawa South; Mr. Pierre Lupien and Mr. Marcel DeBellefeuille, Environmental Protection Service, Ontario Region, National Capital Area Operations, Ottawa. Technical expertise and advice were provided by Mr. Chung Chiu and Ms. Monique Lanoy, Technical Services Branch, River Road Environmental Technology Centre, Ottawa. Analytical tests cited in the report were performed as follows:

- test kit analysis by Mr. Mark Vanderlaan, Environmental Protection Service, Ontario Region, Toronto, and Marcel DeBellefeuille, Environmental Protection Service, Ontario Region, National Capital Area Operations, Ottawa;
- gas chromatography analysis by Mr. C. Beauchemin, Syprotec, Valleyfield, Québec, and Dr. Robert Lao, Technical Services Branch Organic Laboratory, River Road Environmental Technology Centre, Ottawa.

Initial field test kit demonstrations were given at the River Road Environmental Technology Centre by S. Lorne Eason, Centec Analytical Services, Montréal, Québec and subsequently by Mr. Gary Gauger, McGraw-Edison Analytical Services, Frankville, Wisconsin, U.S.A., for the Centec/McGraw-Edison Kit and by John Beck, Syprotec, Pointe Claire, Québec, for the Kwik-Skrene Test Kit.

APPENDIX A
MANUFACTURERS' TECHNICAL DATA

New from McGraw-Edison:
PCB field test kit for screening oil and soil

Simple to operate.
Inexpensive.
Portable.
Fast.

McGraw-Edison Power Systems Division has announced the introduction of a PCB field test kit* for determining PCB concentration levels in electrical apparatus oil. About the size of a weekend bag and just as easy to carry, the McGraw-Edison PCB Field Test Kit provides a fast, inexpensive, on-site method to accurately identify transmission and distribution equipment contaminated with PCBs. Soil testing equipment, which fits in the same case, also is included. The combination oil/soil kit reduces handling and storage, and saves time.

DESCRIPTION

The PCB field test kit (Figure 1) is used to screen dielectric fluid for PCB contamination, combining a simple, three-step chemical procedure with electronic measurement and digital readout. Designed for use in the field, the PCB field test kit is battery operated and, weighing only 16 pounds, is fully portable.

The PCB field test kit features:

- Rapid determination of PCB contamination level.
- Emergency on-site analysis.
- Simple, three-step procedure.
- Operation by nontechnical personnel.
- Low cost per sample.
- Excellent precision and accuracy.

APPLICATION

On May 31, 1979, the Environmental Protection Agency (EPA) published the PCB Ban Rule in the Federal Register, establishing criteria for three levels of PCB contamination in dielectric fluids:

- PCB levels greater than 500 ppm: PCB fluid.
- PCB levels from 50 to 500 ppm: PCB-contaminated fluid.
- PCB levels less than 50 ppm: Non-PCB fluid.

The field test kit is a quick and economical means of estimating actual PCB contamination. The contamination is determined by comparing the kit's digital meter response to a corresponding table of PCB parts per million.

*Developed and originally marketed by Centec Analytical Services Division of Centec Corporation, the PCB Field Test Kit has been added to the McGraw-Edison Power Systems Division line of products to broaden our service to customers. Assembly and quality testing of kits are being performed by our Thomas A. Edison Technical Center.

Figure 1.
McGraw-Edison's new PCB field test kit.

Routine Testing

The regulations specify that a mineral oil transformer must be considered a PCB-contaminated transformer unless tests prove otherwise. The kit can perform in a routine test program to provide this proof.

Critical Locations

The EPA requires that transformers be removed or proven not to contain PCBs if they are in critical environmental areas, such as near food processors or water supplies. The kit facilitates compliance and reduces associated costs.

Repair and Maintenance

Many management and union policies now require that a PCB analysis be performed before a transformer can undergo servicing or repair. The kit eliminates costly delay.

McGRAW-EDISON

Choice without compromise.

HL

PCB Spills

In the event of a dielectric liquid spill, the kit can assess environmental risk on site, immediately. If PCB is present, the soil testing equipment provides quick readings before and during clean-up, thus saving time and costs.

FIELD TEST PROGRAM

The PCB field test kit can be set up at the site of each transformer or other apparatus, or at a convenient sample collection point. The kit must be calibrated before the first sample is tested; thereafter, it must be calibrated hourly or each time it is moved to a new site. After the kit is calibrated, each oil sample can be analyzed in five minutes, using a simple, three-step process:

1. Fit a clean disposable pipet tip to the 1-mL pipetor. Use the pipetor to transfer a sample of the oil to a reaction vial containing premeasured reagents. Cap the vial and shake for 20 seconds.
2. Use the 5-mL pipetor to transfer the oil extraction fluid to the reaction vial. Cap the vial and shake for ten seconds. Wait two minutes for the two layers to separate.
3. Rinse and dry the probe. Immerse the probe in the lower layer. Mix gently for two minutes. Record the probe response on the permanent record sheet and note the contamination level.

The PCB field test kit offers excellent accuracy (±20%) in comparison with laboratory analysis and precision (±5%) in duplicating results. This level of accuracy becomes critical only near the EPA category limits of 50 and 500 ppm. Therefore, the kit incorporates in its analysis chart and table the two safety ranges (TEST-50 and TEST-500) where laboratory analysis is recommended for confirmation.

Experience with this kit has shown that, as a rule, approximately 70 of every 100 transformers tested can be classified as non-PCB transformers and will require no further action. For these, then, servicing or repair could begin as soon as the five-minute test is complete. Some of the remaining 30 transformers may fall in the TEST-50 or TEST-500 range, and for these, laboratory confirmation would be recommended.

SOIL TESTING EQUIPMENT

To facilitate on-site soil testing in the event of a suspected PCB oil spill, soil testing equipment (Figure 2) is also included in the kit. The easily assembled, three-ft-long soil collector (designed for use from a standing position) picks up soil in ½-in. depths, so that a number of samples of near-uniform depth can be quickly gathered over a prescribed area. The collected soil is then mixed with an equal weight of soil extraction solvent and allowed to settle. The soil extraction solution can then be tested in accordance with the standard three-step procedure used in testing dielectric fluid.

Figure 2.
Demonstration of soil collector. (Safety procedures may be required in actual use)

COST COMPARISON

Using the PCB field test kit, testing can be performed at a fraction of the cost of laboratory analysis. Figure 3 compares the cost of kit analysis with the cost of gas chromatography (GC) analysis, in terms of the number of samples analyzed.

The curve for GC analysis assumes an average of $65 per sample for laboratory testing (based on estimates of the Electric Power Research Institute). The curve for kit analysis reflects only direct analytical cost. The saving demonstrated does not include time and labor saved by using the kit.

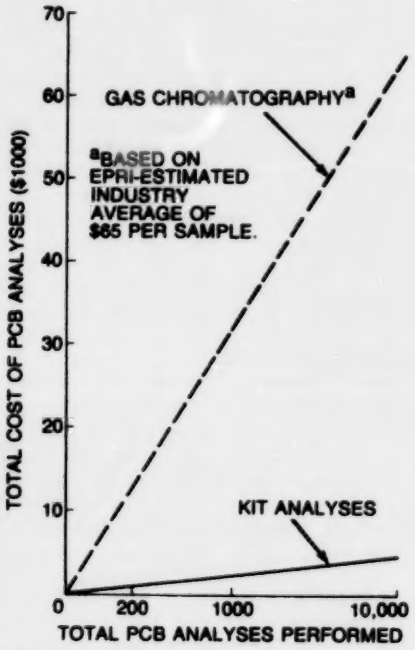


Figure 3.
Cost comparison: Kit analysis and gas chromatography.

ADDITIONAL INFORMATION

For additional information about the McGraw-Edison PCB Field Test Kit, contact your McGraw-Edison representative, or write to McGraw-Edison Company, Power Systems Division, PO Box 2850, Pittsburgh, PA 15230. In Canada, write to McGraw-Edison Limited, 3595 St. Clair Avenue East, Scarborough, Ontario, M1K 1M1. Telephone: (412) 777-3200.

NOTE: The PCB Test Kit can be purchased under GSA Schedule Contract No. GS-00S-5611 from March 11, 1983, to March 10, 1984.

McGRAW-EDISON

Bulletin 83029
October 1983 • New Issue

Power Systems Division
McGraw-Edison Company
Post Office Box 2850
Pittsburgh, PA 15230

SYPROTEC INC.

PCB KWIK-SKRENE KIT

The PCB KWIK-SKRENE KIT will detect the presence of PCB's (Polychlorinated Biphenyls) in dielectric fluids. This simple wet chemical kit is based on the conversion of chlorine in chlorinated hydrocarbons (such as PCB's) into chloride ions. These chloride ions are then detected by a colour-forming reaction. The method has been developed by BC Hydro Research & Development and has been successfully tested in the field for the past two years.

The portable KWIK-SKRENE KIT is easy to use, requires no instrumentation and consists of pipettors, chemical reagents & standard solutions.

Each oil sample being tested is dispensed into separate test tubes. BLANK & CONTROL solutions are also prepared as standards against which the oil samples are compared. REAGENTS "A", "B" & "C" are sequentially dispensed into each test tube using the pre-calibrated micropipettors. The solutions are allowed to settle for a minute until two layers develop; the bottom layer is the one under consideration.

The test tube with the BLANK solution (10 ppm PCB Aroclor 1260 in mineral oil) will have a white colouration. The test tube with the CONTROL solution (35 ppm PCB Aroclor 1260 in mineral oil) will have a light orange colouration.

Oil samples under consideration that have a bottom layer with a lighter shade of orange than the CONTROL contain less than 35 ppm of PCB's. Those with a darker shade of orange contain more than 35 ppm of PCB's.

An average of fifty PCB-in-oil determinations can be performed with the KIT. Testing one or several samples in the field requires no more than a few minutes and can be performed by your maintenance crew.

When the original stock of reagents & disposable glassware is exhausted, only the P50R REPLENISHING KIT need be ordered, thereby keeping your cost to less than $5.00 per test.

DESCRIPTION

P50C PCB KWIK-SKRENE TEST KIT contains all of the necessary hardware, chemical reagents & standard solutions needed to perform an average of fifty tests.

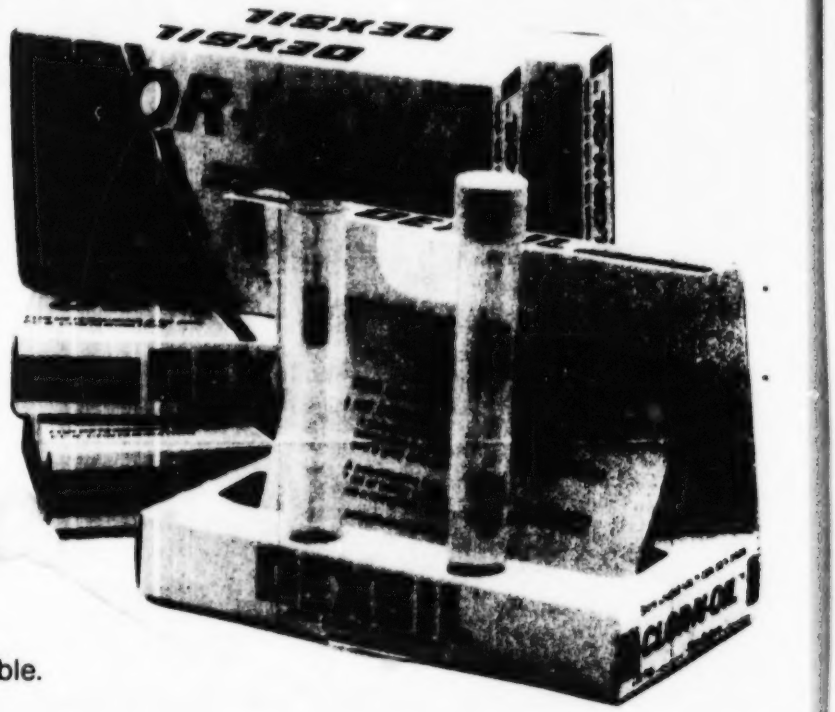
P50R PCB KWIK-SKRENE REPLENISHING KIT contains all reagents, standard solutions & disposable glassware needed to perform an average of fifty tests.

SYPROTEC INC.
235 PLACE FRONTENAC
POINTE-CLAIRE, QUEBEC
CANADA H9R 4Z7

TELEPHONE: 514-694-3637
TELEX: 05822699 ANALTRAD PCLR

CLOR·N·OIL™
PCB Screening Kit

Test for PCBs in Under 4 minutes right on the spot!



The CLOR-N-OIL PCB Screening kit is designed to detect the presence of PCBs (polychlorinated biphenyls) in transformer oil. Each kit is individually packaged containing pre-measured reagents in sealed crushable glass ampules. The ampules are broken selectively and the final color of the solution indicates the presence or absence of PCBs.

The CLOR-N-OIL PCB Screening Kit is the ultimate in portability, simple to use, quick, safe and extremely dependable.

Each kit consists of two polyethylene test tubes, each containing pre-measured reagents. Also included in every kit is a polyethylene pipette that is used to draw the oil sample. After the test is complete and the results recorded, the entire kit is disposed of, eliminating the chance of contamination of future tests.

The kit uses a color-forming reaction to show the presence of PCBs. Any shade of blue or purple color indicates the oil contains less than 50 ppm PCBs and the transformer can be labeled "non-PCB". If the resulting color is yellow then the oil needs further testing to determine the exact PCB content.

The CLOR-N-OIL PCB Screening Kit allows the user to "screen" out contaminated oils, thus eliminating much of the gas chromotography testing that is both slow and expensive. The test can be performed right in your workshop by maintenance personnel or on-site in the event of a spill or critical situation.

With the CLOR-N-OIL PCB Screening Kit transformer oil can be tested for as little as $4.00 per sample. The kits are packaged in lots of 20 and are all you need. There is no expensive and delicate equipment required. With experience showing that 8 out of 10 transformers are under the 50 ppm limit, the CLOR-N-OIL PCB Screening Kit offers monumental savings over laboratory testing methods.

DEXSIL

DEXSIL CHEMICAL CORPORATION
295 Treadwell Street • Hamden, CT 06514
(203) 288-3509

TM An Electric Power Research Institute trademark

The development work for this kit was sponsored and funded by EPRI, and carried out by General Electric Company and Dexsil Chemical Corporation.

October, 1984

CLOR·N·OIL™
PCB Screening Kit

PRICE STRUCTURE

		PRICE PER SHELF PACK	PRICE PER CASE	COMPARATIVE PRICE PER KIT
1 - 3 SHELF PACKS	(20 - 60 kits)	$120.00		$6.00
1 - 4 CASES	(80 - 320 kits)		$400.00	$5.00
5 - 9 CASES	(400 - 720 kits)		$360.00	$4.50
10 - 14 CASES	(800 - 1120 kits)		$340.00	$4.25
15 - 24 CASES	(1200 - 1920 kits)		$320.00	$4.00
25 - 49 CASES	(2000 - 3920 kits)		$300.00	$3.75
50 CASES & OVER	(4000 - kits)		$280.00	$3.50

1 Shelf Pack contains 20 kits
1 Case contains 4 Shelf Packs (80 kits)
Minimum order, 1 Shelf Pack (20 kits)

NOTE: **CLOR-N-OIL 50** KITS AND **CLOR-N-OIL 500** KITS MAY BE COMBINED IN MULTIPLES OF 20 TO OBTAIN MAXIMUM DISCOUNT.

TERMS: NET 30
DELIVERY: FROM STOCK
FOB: HAMDEN, CT
NOTE: ALL PRICES IN U.S. CURRENCY

Price and terms subject to change without notice.

DEXSIL®
DEXSIL CHEMICAL CORPORATION
295 Treadwell Street • Hamden, CT 06514
(203) 288-3509

• Dexsil Chemical Corporation
™ CLOR-N-OIL IS AN ELECTRIC POWER RESEARCH INSTITUTE TRADEMARK

APPENDIX B
LABORATORY EVALUATION STUDY

PRELIMINARY EVALUATION OF PCB FIELD TEST KITS

by

C.H. Chiu
Analytical Services Division
Technical Services Branch
River Road Environmental Technology Centre
Environmental Protection Service
Environment Canada
May 1984

I CENTEC PCB FIELD TEST KIT (McGraw-Edison Company)

1. Principle

PCB molecules are chemically destructed to form chloride ions, which are extracted and measured with a specific ion electrode.

2. Capability

PCB contaminated transformer fluids can be screened into three levels:

a) less than 50 ppm;
b) 50 to 500 ppm;
c) greater than 500 ppm.

3. Advantages

a) Procedures are simple and easy to follow.
b) Sample can be analyzed in five minutes.

4. Disadvantages

a) It is not specific to PCBs; other chlorinated hydrocarbons (i.e., chlorobenzenes) present in the sample will be detected and counted as PCBs.
b) It cannot determine the Aroclor type of PCBs present in the sample.

5. Laboratory Test

The first and second probes (ion electrode) received had some defect, so that a third probe was requested. Calibration test was performed satisfactorily using the third probe. PCB standards Aroclor 1260, 1254 and 1242 were spiked individually into

into mineral oil and measured by using the PCB kit. Two probe response charts, one for Aroclor 1260 and the other for Aroclor 1242, were provided with the kit for quantification. We used the average of the two charts for quantification of Aroclor 1254. Experiment results are tabulated below:

Type of PCBs	Spiked in Mineral Oil	Probe Response	Chart Reading
Aroclor 1260	50 ppm	85 mV	22 ppm
Aroclor 1242	50 ppm	88 mV	49 ppm
Aroclor 1254	50 ppm	84 mV	43 ppm
Mineral Oil Blank	None	130 mV	0

Good agreement was obtained for Aroclor 1242. However, a large discrepancy between the chart reading and the actual PCB value was observed for Aroclor 1260. The explanation given by the company (Mr. Gary Gauger, Supervisor, Analytical Services of McGraw-Edison Company) was that the probe response chart for Aroclor 1260 has been compensated for the askarels which not only contain PCBs but also trichlorobenzene (up to 50%). Since the spiked sample prepared in the lab does not contain any trichlorobenzene, a much lower PCB value measured by the probe is expected. The askarel used in Canada is expected to contain mainly Aroclor 1260 and trichlorobenzene.

II PCB "KWIK-SKRENE" TEST KIT

1. Principle

Its chemistry is based on the conversion of chlorine in chlorinated hydrocarbon materials into chloride ions. The chloride ions are then detected by a colour-forming reaction.

2. Capability

It screens transformer fluids for the presence of PCBs about or below 35 ppm.

3. Advantages

a) Procedures are simple and easy to follow.

b) Sample can be analyzed in five minutes.

4. **Disadvantages**

a) It is not specific to PCBs; other chlorinated hydrocarbons present in the sample will be detected and counted as PCBs.

b) It cannot determine the Aroclor type and exact concentration of PCBs.

c) Reagents must be stored in refrigerator for longer life.

5. **Laboratory Test**

Reagent B and reagent C required for this PCB kit have been changed twice by the company during the last few months. The new products (reagent B and C) are supposed to improve colour appearance and consistency.

PCB standards of Aroclor 1260 and 1242 were spiked individually into mineral oil at concentrations of 10, 35 and 50 ppm. Light brown-orange colour was observed at 10 ppm and colour intensity increased with the increasing of PCB level. One can easily tell the colour difference between 10 ppm and 35 ppm. However, there is no significant difference in colouration between 35 and 50 ppm. The last step of shaking with reagent C is very crucial. Too much shaking will result in over colouration and may give a sample or even the blank a false positive indication. Some practice is required in order to obtain consistent results.